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Short Communication

Aligning EU policies to address biological invasions: assessing invasion impacts across sectors

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Abstract

Invasive alien species (IAS) affect various policy sectors, including environment, trade, and agriculture. In Europe, each of these sectors is usually regulated under different European Union legislation, but IAS is not prioritised in most sectors, and this may hinder effective tackling of biological invasions. Greater policy coherence is needed to align relevant sectors for better management of biological invasions. Engaging policymakers by sharing information on IAS impacts can help them understand the multisectoral nature of the problem and develop effective strategies.

We reviewed 602 IAS in Europe, impacting nine policy sectors and 25 domains (i.e. specific policies within a broader policy sector, each addressing particular issues and activities related to that sector portfolio). Findings were presented at the NeoBiota workshop in Lisbon on the 3rd of September

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2024, attended by 54 participants, including policymakers and researchers. The workshop featured presentations and interactive sessions where participants tested the review methodology on 49 species, identifying areas for improvement, such as assessing impact scale and refining sector domains. Confusion matrices showed moderate to substantial agreement between organisers and participants in evaluating affected domains, types of impact, and confidence levels.

This study shows the crucial need for interaction and synergy between research and policy, which are essential for tackling effectively IAS in Europe.

Key words: Biodiversity, impact, invasive alien species, policy domains, workshop

Introduction

Invasive alien species (IAS) impact multiple policy sectors and the related activities, requiring effective and coordinated management. These impacts can be perceived as negative or positive and span across environment, economy and human health (Havel et al. 2015; Mollot et al. 2017; Katsanevakis et al. 2018; Fleming et al. 2023; IPBES 2023). These sectors are regulated under European Union legislation (i.e. addressing all Member States) that may however not fully address biological invasions (COM (2021) 628 final). In this study, we refer to "policy sectors" as areas of European public policy that are clearly defined by the issues and activities they address (e.g. agriculture, fisheries) and to "domains" as the specific policies related to that sector issues and activities portfolio (e.g. forestry, soil, aquaculture) (Table 1). These policy sectors may encompass broader governance and regulatory aspects that go beyond the economic activities of a sector. Therefore, while these policy sectors can include economic sectors by addressing the broader context in which these economic activities occur, the focus of this study does not include monetary assessment.

Access to sector-wide scientific assessments of IAS impacts is limited and hindered by lack of comprehensive linkages to affected domains (Table 1). This is likely due to the limited attention given to the prioritization of IAS in sectors other than biodiversity, resulting in lack of unifying metrics for assessing their impact. As a result, clear and usable sector-wide information on IAS impacts would help to explicitly consider policy trade-offs, improving coherence and policies coordination for IAS prevention and control (Bray et al. 2024).

Negative impacts of IAS extend across terrestrial, freshwater, and marine environments. Research has increasingly highlighted the effects of IAS on biodiversity (Pyšek et al. 2020), i.e., on native species, community diversity (Çinar et al. 2014), and on ecosystem services (Gallardo et al. 2024). In recent years, several studies have also shown that IAS can cause substantial economic losses (Cannarozzi et al. 2023) and management costs (€116.61 billion in Europe, Haubrock et al. 2021), which can be linked to sector-specific impacts. Costs and benefits can span across multiple sectors and may not necessarily balance each other out (Carneiro et al. 2024). These encompass, for example, animal and human health (Shackleton et al. 2019a; Chinchio et al. 2020; Roy et al. 2022; EFSA 2023), water resources (Watts and Moore 2011; Lamb et al. 2021), energy systems (Booy et al. 2017), transportation systems (Nyumba et al. 2021; Vanderbush et al. 2021), forest and grassland (Rojas-Sandoval et al. 2022), and indigenous people (Pfeiffer and Voeks 2008; Pretty Paint-Small 2013; Shackleton et al. 2019b). Furthermore, research has also demonstrated that IAS can provide benefits to human well-be-

Table 1. Policy sectors and sector domains considered in this study. Columns represent categories of policy interest regulated by European legislation considered as thematic areas to which the impact of IAS can be attributed, considering physical, chemical, biological and functional characteristics (e.g., soil) or policy initiatives (e.g., nature protection and restoration). '*' indicates domains identified during the workshop. For biodiversity specifically, impacts on biodiversity components are not further refined, and all impacts on biodiversity are grouped into the "nature protection and restoration" domain.

Main policy sectors	*Sector domains*	*Description of areas covered by the domain*
Agriculture and Rural development (AGRI)	Agriculture	Crop production, livestock, agricultural ecosystems
	Soil	Soil quality, structure, nutrient cycling
	Forestry	Forest health, tree species' diversity, timber production
Mobility and Transport (**TRANSPORT**)	Security and safety	Risks to transport and infrastructures safety through physical obstructions and hazards
	Infrastructures (road, rails, canals)	Integrity and maintenance of transport infrastructures
	Inland waters (related to transport)	Navigability and ecosystems' health
	Maritime (Port)*	Port operation, ships hulls and marine logistics
Energy, Climate change, Environment (**ENERGY**)	Security (in terms of production and supply)*	Disruption to energy supply chains and production facilities
	Efficiency (relates to energy consumption, therefore IAS impact which causes increased use of energy, etc.) *	Energy consumption including increased demand for control measures
	Renewable energy (IAS invading/damaging canals/plants, etc.)	Renewable energy infrastructure such as hydroelectric plants and solar fields
Health and Food Safety (**SANTE**)	Animal health	Livestock health and veterinary biosecurity
	Plant health	Crops' health, plants biosecurity, agricultural biodiversity
	Food and feed safety (contamination, allergens, pathogens, seeds, toxins, etc.)	Contamination of food and feed supply
	Human health	Allergens, diseases, physical injuries
Internal Market, Industry, Entrepreneurship and SMEs (**GROW**)	Industry (affecting business competitiveness, growth and resilience, e.g. Coronavirus, etc.)	Competitiveness and resilience
	Small and Medium Enterprises (SMEs)	Operations and market access
	Internal market/trade	Trade regulations, market stability, cross-border commerce
Directorate-General Climate Action (**CLIMA**)	Greenhouse Gas emissions (IAS which may increase gas emissions)	Greenhouse gas emissions through ecosystem changes
Energy, Climate change, Environment **(Environment)**	Clean water (water quality)	Water quality and availability in freshwater ecosystems
	Marine environmental status	Marine biodiversity and ecosystem health
	Nature protection and restoration (all biodiversity related impacts) (NPR)	Natural habitats, biodiversity, conservation efforts
Maritime affairs and fisheries (**MARE**)	Fisheries (including freshwaters)	Fish populations, habitats, fishing industries
	Aquaculture	Aquaculture practices and production
	New bio industries*	Opportunities and challenges in emerging biological industries
	Energy (energy consumption)	Energy use within marine and fisheries sectors
	Tourism	Tourism activities, attractions, natural landscapes
Regional and Urban Policy (**REGIO**)	Urban areas/regions	Urban environments, infrastructures, and community well-being

ing, thus suggesting a multifaceted dimension of their impacts. Positive impacts may encompass provisioning services (food, medicines, bioenergy, and construction materials), regulating services (bio-agent control, bioremediation and shade provision), cultural services (aesthetic and ornamental values), and supporting services (soil and land reclamation through eco-restoration) (Katsanevakis et al. 2014; Cerveira et al. 2022; Barcellos et al. 2023; Marchessaux et al. 2023; Boadie-Ampong et al. 2024). While researchers investigated the impacts of IAS, im-

portant gaps remain in linking the comprehensive assessment of IAS impacts to policy sectors and domains.

Protocols used in the framework of the EU Regulation 1143/2014 on IAS do consider current and future impacts on provisioning, regulating and cultural services as well as impacts on human health, safety and the economy (Commission Delegated Regulation (EU) 2018/968 of 30 April 2018, Art 5(1)(f)). Yet, these impacts are described rather qualitatively, considered as aggravating factors and do not match the need to mobilise available information linking impacts across different policy sectors. The pioneering efforts of the InvaCost database provide an initial quantification of the economic impacts of biological invasions (Diagne et al. 2020), offering a foundational assessment of the financial burdens imposed by IAS across various sectors (Turbelin et al. 2024). To address the inherent challenges in evaluating these impacts, there is a pressing need for a standardised framework that includes consistent sectoral definitions and metrics. This would enhance the interoperability of impact assessments across different sectors, facilitating more coherent and comprehensive analyses.

The European Union's regulatory framework plays a crucial role in addressing the complex and cross-sectoral issue of biological invasions. While specific regulations, such as the EU IAS Regulation (1143/2014/EU), the Plant Health (2016/2031/EU) and the Animal Health legislation (2016/429/EU), set out the obligations for preventing and managing IAS, the effects of biological invasions are far-reaching and impact various other sectors that are governed by EU legislation, but which do not explicitly address IAS. In this complex landscape, several policies often guide decisions on different aspects of the same topic, while each individual policy may tackle more than one challenge (e.g. biodiversity loss, water quality, protection of livelihood), highlighting the need for a coordinated and coherent approach. One example of such complexity is the case of *Robinia pseudoacacia*. In the phytosanitary sector, efforts are made to eradicate this species due to its invasive nature. However, contrasting policies exist where subsidies are provided to encourage its planting to support bees and honey production. This contradiction underscores the necessity for coherence and alignment across policy areas to effectively manage biological invasions. By recognising and addressing these overlaps and mismatches, the EU can develop more integrated and effective strategies to manage IAS and their impacts across different sectors. Therefore, effective policy making to address the complex topic of biological invasions requires a comprehensive understanding of the entangled relationships between various policy sectors, and the issues and activities managed, grounded in a strong scientific base (IPBES 2023).

To this end, the European Alien Species Information Network (EASIN) of the Joint Research Centre (JRC) of the European Commission has collected qualitative information on the positive and negative impacts of 602 IAS on 9 policy sectors and 27 sector domains in Europe (Suppl. material 1). This first compilation of impacts across sectorial domains (herein after primary assessment) aims at facilitating the exchange of information among policymakers and scientists, and between those active in different policy sectors and sector domains, and to identify gaps and challenges e.g. which sectors would benefit from more explicit inclusion of IAS to mitigate their impacts, or defining tailored biosecurity plans that address specific sectors, promoting a more effective and sustainable management of IAS. The preliminary results of this review were presented and discussed with international experts at the NeoBiota workshop in Lisbon on the 3rd of September 2024,

to agree on methodology, and identify areas for improvement. The main aim of the workshop was to provide the scientific community and authorities' representatives, with an overview of the data compiled, to test the methodology on a subset of information to gain an understanding of the suitability of the approach, and any potential application difficulties. In the following sections, we provide a summary of the primary assessment and highlight the main outcomes of the workshop.

Primary assessment

A sample of 602 IAS was extracted from the EASIN Catalogue. The selection of the IAS considered plant and animal species across freshwater, terrestrial, and marine environments, and was based on their impact as identified from several data sources. For these species, data on impacts were extracted from both scientific and grey literature, using the Web of Science, Scopus, Google Scholar, and Google, which were accessed in June 2024. The following keywords were entered into the search engines: "impact* of [species name] on [domain], OR "effect* of [species name] on [domain]", OR "influence* of [species name] on [domain]" OR "species [name] and [domain] impact*", "how [species name] affect* [domain]", OR "effect* of [species name] on [domain]", OR "influence* of [species name] on [domain]", OR "[species name] and [domain] interaction*". Based on this review positive and/or negative impacts of species across 27 sector domains (Table 1) were assessed by a team of eight experts with taxonomic and ecological expertise (i.e. primary assessment). This assessment focused solely on impacts in invaded ranges within Europe. However, in case of a lack of literature to support impact in Europe, references from other areas were also considered. For species partly native in Europe, impacts from the native range area were not considered. A two-step process was adopted. Initially, several hundred IAS were assessed by four experts. Subsequently, these IAS were reviewed by other four experts to identify discrepancies and ensure a consistent understanding of the domains and assessment protocol. The assessment then proceeded to complete the evaluation of all 602 IAS.

A confidence level (Suppl. material 1: Table S1) was assigned to each species' impact using a framework that considers the nature, coverage, quality and consistency of evidence (Suppl. material 1: Table S1) of the highest (negative or positive) reported impact. Positive and negative impacts can be documented for the same species within the same domain or across different domains (Table 2).

Table 2. Definitions of impact types, i.e. negative and positive, modified from Vimercati et al. (2022). DD refers to data deficient information.

Impact type	Definition
negative	A decrease in a policy sector attribute, value-free (i.e. not influenced by human ethical values) driven by IAS. Negative impacts are reported considering the availability of relevant studies in a policy sector. E.g. *Halyomorpha halys* in agriculture: damaging a wide variety of crops, including fruits, vegetables, and ornamentals. The stink bug feeds on plant tissues, leading to blemishes on fruits and vegetables, which can render them unmarketable. This feeding can also cause deformation and premature fruit drop.
positive	An increase in a policy sector attribute, value-free (i.e. not influenced by human ethical values) driven by IAS. Positive impacts are reported considering the availability of relevant studies in a policy sector. E.g. *Bonnemaisonia hamifera* as a feed supplement for dairy cows. The algae contains bioactive compounds that have the potential to reduce methane emissions during enteric fermentation, a natural digestive process in ruminants that produces methane as a byproduct.
DD	No information to classify the species with respect to its impact, or insufficient time has elapsed since its introduction for impacts to have become apparent.

The selected IAS are reported as having an impact from several data sources, i.e. DAISIE, CABI, GISD, NOBANIS (EASIN protocol). Specifically for species of Union concern under the EU Regulation 1143/2014, the impact is supported by in-depth assessments of experts considering species' negative effects on: i) biodiversity, ii) ecosystem services, iii) economic, and iv) social and human health, following a procedure laid down by Commission Delegated Regulation (EU) 2018/968, outlining minimum standards for risk assessment (Roy et al. 2018).

Impact results

"Nature Protection and Restoration" was the domain most impacted by IAS across policy sectors, with over 300 impacting IAS (Fig. 1). This domain encompasses all types of impacts on biodiversity (e.g. predation, competition for resources, parasitism, etc.). It is followed by Agriculture, Plant Health, Animal Health and Human Health (>100 IAS, Fig. 1). The intersection of these domains and impacting IAS (Fig. 2), shows that Plant Health and Agriculture share the highest number of IAS (>70 IAS), and that approximately thirty IAS are common to all five domains (Fig. 2). Nature Protection and Restoration has a distinct set of 51 IAS that impact on biodiversity (Fig. 2). Fewer than twenty species are unique to each of the Plant, Animal and Human domains respectively (Fig. 2).

The highest number of IAS plants and animals assessed was terrestrial; marine species were the least considered (Suppl. material 1: Fig. S1a). Thirty-one species showed overlap between environments (Suppl. material 1: Fig. S1b).

These domains are characterised by a high confidence in their assessment, thus suggesting robust scientific evidence to support the findings (Fig. 3).

Fig. 3 shows IAS with positive and negative impacts on the same sector. For example, *Ambrosia trifida* is one of the most difficult weeds to manage in many

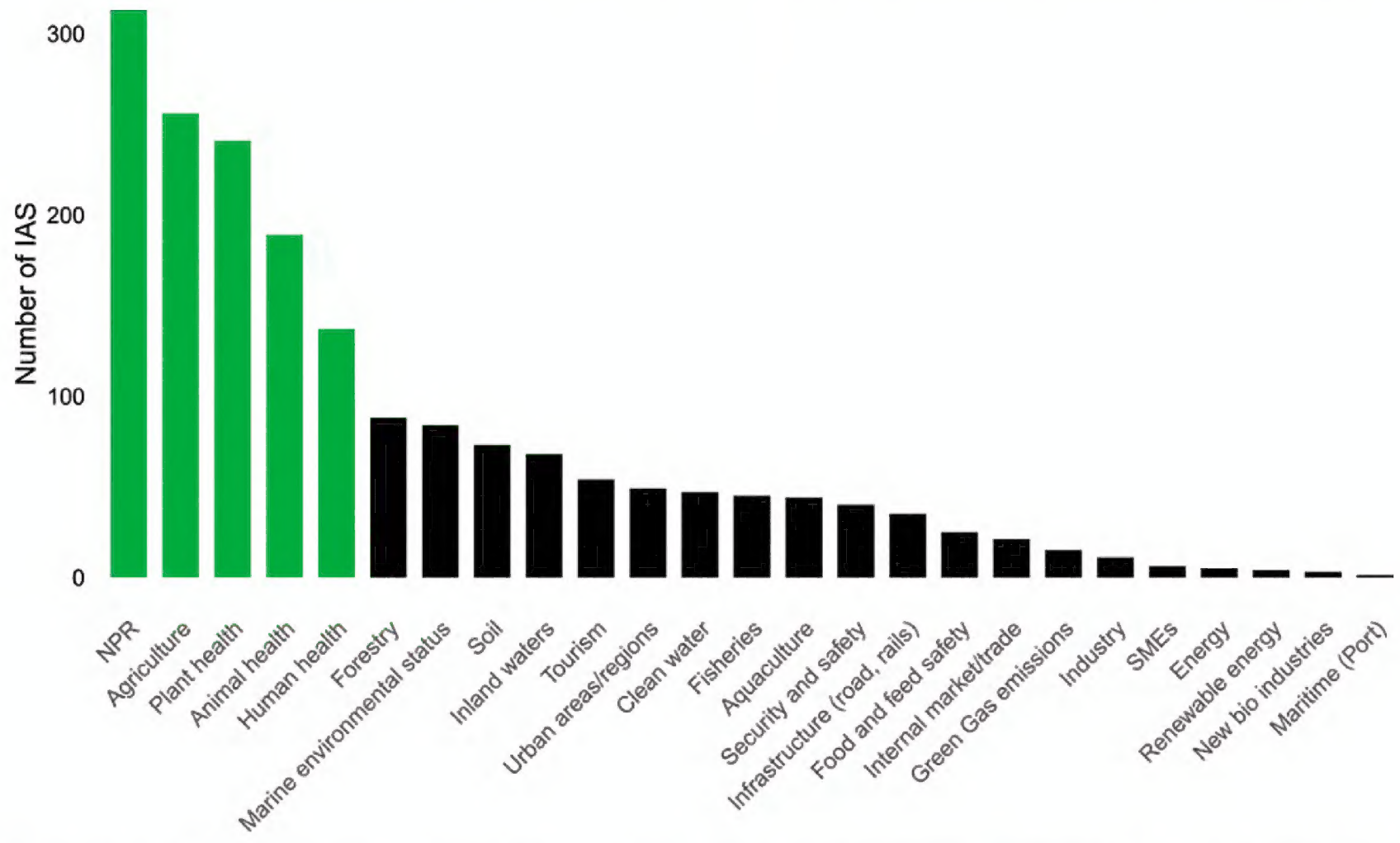

Figure 1. Number of IAS impacting across sectorial domains. Green bars indicate domains with the highest number of impacting IAS (both negative and positive). 'NPR' and 'SMEs' refer to Nature Protection and Restoration and Small and Medium Enterprises respectively (see Table 1 for details).

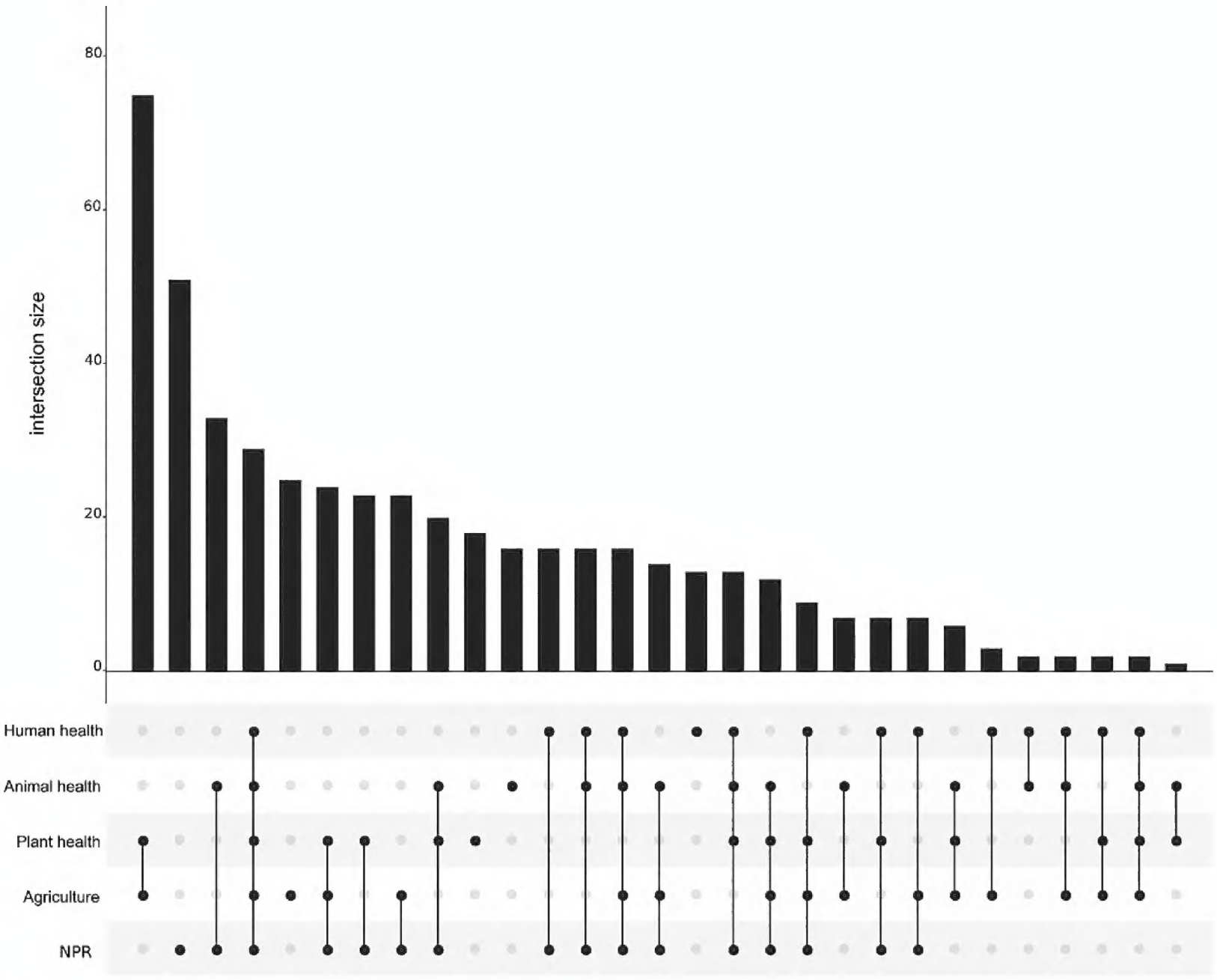

Figure 2. Intersections between the most impacted domains (>100 IAS) i.e., Nature Protection and Restoration ("NPR"), Agriculture, Plant, Animal and Human Health. Number of IAS that are common or unique to domains ('intersection size') as indicated by bottom matrix, which links the domains sharing the same species. 'NPR' and 'SMEs' refer to Nature Protection and Restoration and Small and Medium Enterprises respectively. Upset plot generated using "UpsetR" package (Conway et al. 2017).

countries, resistant to herbicides, and a competitor with crops for light, moisture, and nutrients (Liebman et al. 2020; Kato-Noguchi and Kato 2024). However, it yields considerable amounts of forage of high nutritive value (Bassett et al. 1982; Chauvel et al. 2021) and could be used for phytoremediation and phytostabilisation (Kang et al. 1998).

Negative impacts were by far more prevalent than positive impacts, the latter constituting about 10% to 16% respectively for plants and animals (Fig. 4a, b). However, differences across environments were apparent. For example, animals had a similar percentage of negative impacts on freshwater and terrestrial environments (47.03% vs. 40.17%), whilst plants especially impacted terrestrial environments (76.3%) (Fig. 4a, b). This difference is primarily related to the inherent characteristics of animal and plant taxa. Many animals, such as *Myocastor coypus*, have life cycles that allow them to occupy multiple habitats, leading to a more balanced impact across freshwater and terrestrial environments. In contrast, plants tend to have more localised impacts, predominantly affecting the specific environments they inhabit (e.g. *Acacia dealbata*). This is further influenced by the selection of plant species in our analysis, where we included 215 terrestrial species (including 3 species adapted to muddy floodplains and wet areas, e.g. *Gymnocoronis spilanthoides*) and 38 species exclusive to freshwater environments, and 16 marine IAS. This selection contributes to the observed skew towards terrestrial impacts for plants.

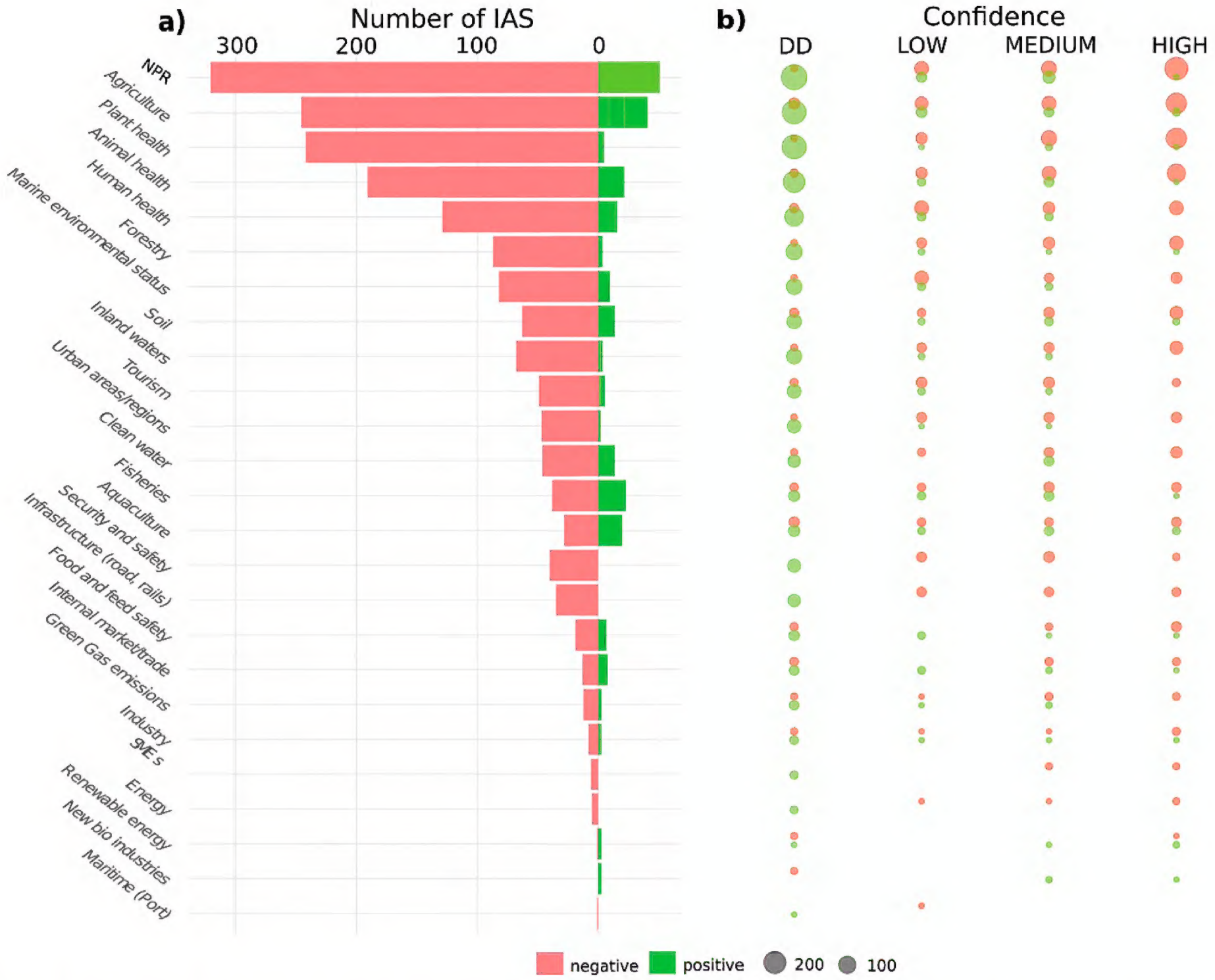

Figure 3. a. Number of IAS that were assessed as impacting negatively and/or positively each sector domain. No impacts were identified for the 'Security' and 'Efficiency' sector domains; **b.** Bubble plot of the distribution of confidence levels for negative and positive impacts across sector domains. The size of each bubble represents the number of IAS that display the corresponding confidence level and impact. DD = data deficient.

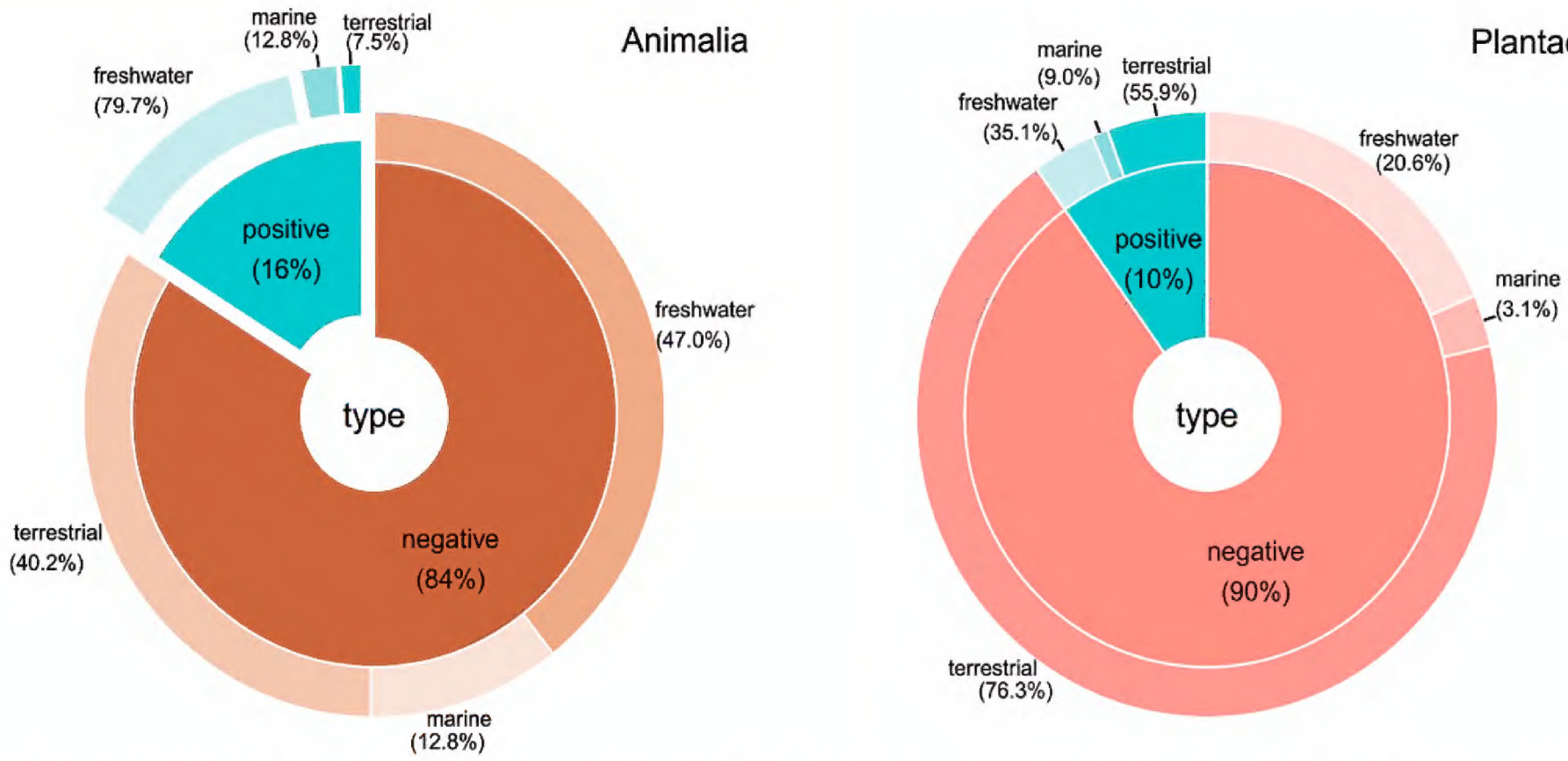

Figure 4. Distribution of impact types across environments: a) Pie-donut chart for Animals (N = 319 IAS) combining positive and negative impacts on freshwater, marine and terrestrial environments. b) Pie-donut chart for Plants (N = 269 IAS) combining positive and negative impacts on freshwater, marine and terrestrial environments.

Workshop

Focus groups

The workshop hosted 54 participants, including representatives from Member State Competent Authorities, experts and researchers. The results of the primary assessment done by EASIN based on the literature review were presented to the participants outlining the aims of the workshop and levelling the understanding of IAS impacts. Following this, nine six-member focus groups applied the review methodology to a subset of 49 IAS (about 5 IAS per group) across environments (Suppl. material 1). These species had already been evaluated in the primary assessment. The groups' work aimed at defining assigned species' primary assessment and to discuss and report on difficulties they encountered in assessing the impacts on the specific policy sector domains, based on the scientific evidence provided. The facilitators presented the participants with an online Google form for compiling the assessment and a guidance per IAS (Suppl. material 1). This guidance contained definitions of types of impact and confidence levels, including excerpts of published texts for each species, which were used in the primary assessment, to help participants in their evaluation. Participants were bound for their evaluation to the information that was provided for each species. The participants within a group collaborated to assess the species. Each of them reviewed the sources, using printed copies of the assessment guidance provided, and reached a consensus for the final evaluation. Consequently, each group completed the Google form once. The assessments from the focus groups were immediately processed for analysis and the results were reported back to the plenary to validate the results and ask for additional inputs.

Outcomes

The EASIN primary assessment identified 23 domains on the subset of 49 IAS, compared to the 27 domains identified by workshop participants (Suppl. material 1: Fig. S2). Four new domains impacted either negatively or positively by these IAS were identified: Maritime (Port) including inland (e.g., for *Asparagopsis armata*, *Myriophyllum aquaticum*, *Styela clava*), New Bio Industries (e.g., for *Asparagopsis armata*, *Arundo donax*, *Corbicula fluminea*, *Metapenaeus stebbingi*, *Grateloupia turuturu*), Energy and security (e.g., *Castor canadensis*, *Arundo donax*, *Myriophyllum aquaticum*, *Neltuma juliflora*, *Eucalyptus camaldulensis*), and Energy efficiency (e.g., *Corbicula fluminea*, *Myriophyllum aquaticum*, *Ctenopharyngodon idella*, *Styela clava*). These new domains either replaced proposed ones or were added. For example, the marine red alga *Asparagopsis armata*, initially assessed as impacting the "Marine Environmental Status" domain, was instead indicated as impacting "Maritime (Port)". For other species, such as the Asian clam, *Corbicula fluminea*, participants also identified additional impacted domains. Unlike the EASIN primary assessment, which identified 27/49 species with both positive and negative impacts, workshop participants identified 24 species, with a greater disparity between negative and positive impacts (Suppl. material 1: Fig. S3). One possible explanation for this discrepancy could be the limited time and training available to participants during the workshop, which might have influenced their ability to fully consider and evaluate both types of impacts. Additionally, experience bias may have played a role, as participants might have been more influenced by their personal experiences or prevailing narratives, leading to a skewed perception of the impacts.

Confusion matrices and Cohen's Kappa (Cohen 1960) were used to evaluate agreement between the primary assessment and workshop participants for each IAS, sector domain, impact type, and confidence level (Table 3a–c). The results indicated moderate ($0.41 < \varkappa < 0.60$) to substantial ($0.61 < \varkappa < 0.80$) agreement across all areas (Landis and Koch 1977), suggesting an overall good consistency.

Discussions insights

Participants highlighted key challenges in assigning IAS impacts on policy sectors and domains, underlining the need for continued research, collaboration, and the development of more refined tools for cross-sectoral assessments of IAS impacts. Furthermore, three main issues were raised by participants:

First, the scale of impacts. Participants noted the uncertainty in the assigned impacts due to geographical scale. The impacts can vary significantly depending on regional, ecological, economic, and social contexts, necessitating a more nuanced approach that considers geographical and contextual differences. A case in point is *Codium fragile* subsp. *fragile*, commonly known as green sea fingers, which has been found to impact *Fucus serratus*, another seaweed species, but only on the southwest coast of Norway, where a specific study was conducted (Armitage et. al 2014). This geographical variability in impacts poses a significant challenge in developing coherent European policies and management strategies. As a result, it is recommended that the assessment specifies the geographical areas where this impact has been recorded. Furthermore, the lack of empirical evidence for certain species in natural environments presents a substantial challenge, particularly for species assessed to have significant impacts in areas such as agricultural pest

Table 3. Cohen's Kappa per sector domain, impact type and confidence level (for positive and negative impact types). Numbers show the detailed classification results of the primary assignment and workshop participants on the IAS subset (49 IAS) across domains, negative and positive impacts and related confidence levels.

a) Sector domain			
Kappa	54%		
Proportion of observed agreement	80%		
Proportion of agreements expected by chance	55%		
b) Impact type			
	Negative		**Positive**
Kappa	60%		71%
Proportion of observed agreement	79%		90%
Proportion of agreements expected by chance	49%		65%
c) Confidence level			
NEGATIVE	**High**	**Medium**	**Low**
Kappa	63%	57%	61%
Proportion of observed agreement	81%	78%	86%
Proportion of agreements expected by chance	49%	50%	66%
POSITIVE	**High**	**Medium**	**Low**
Kappa	80%	59%	69%
Proportion of observed agreement	97%	84%	90%
Proportion of agreements expected by chance	85%	60%	67%

management and biodiversity. The existing literature tends to focus on mitigating specific impacts, while future research should explore the underlying mechanisms driving these impacts.

Second, considering positive and negative impacts of a species in its native environment. For example, *Misgurnus anguillicaudatus*, the dojo loach, can have a positive effect on rice cultivation, by potentially controlling pests and weeds (Clavero et al. 2015). It serves as an important food source for many aquatic birds, including herons, gulls, ducks, and waders (Clavero et al. 2015). However, the high availability of the dojo loach in rice fields can trigger hyper-predation processes, driving the decline of native taxa (Clavero et al. 2015). Finally, *M. anguillicaudatus* is a high-demand species for aquaculture in several East Asian countries (Yan et al. 2017). This example highlights the complex and multifaceted nature of ecological interactions, emphasising the need for a comprehensive understanding of these impacts. The goal is to ensure that management decisions are informed by a balanced view of all potential outcomes, thereby promoting sustainable ecological practices.

Participants also raised concern over the challenge of assigning confidence levels to impacts, especially when existing evidence is biased. Future research plays a key role in impact evaluation and to provide information for balancing positive and negative impacts of IAS. To this end, the consensus on how to consider confidence is fundamental, and should be aligned with the robustness of collected evidence, to stress the need for selecting robust references across geographical areas. Participants also highlighted the importance of including independent sources (e.g. multiple, unbiased entities), even if they refer to single study cases, particularly for emerging pests.

Third, refining the sectorial domains categories would enable a more nuanced understanding of IAS impacts. For example, *Corbicula fluminea*, a species that has been included in the categories "Nature Protection and Restoration" and "Industry", has more specific impacts, including biofouling and effects on power generation and water treatment industries (NNSS 2015). Workshop participants suggested that refining the sectoral domain categories with subdivisions would better link the impacts of IAS to the relevant domains. For example, the broad domain of 'Nature Protection and Restoration' could be divided into subcategories, thereby allowing the leveraging of existing work on biodiversity impacts, e.g. the EICAT framework (Blackburn et al. 2014; Hawkins et al. 2015).

These three groups of recommendations were prioritised for action, considering future developments of the primary assessment in a policymaking context.

Conclusions

This study has highlighted gaps and opportunities in the current understanding and assessment of IAS impacts across policy sectors and domains.

The impact assessment approach requires acknowledging the complexity of evaluating diverse impacts across numerous sectoral domains. The foundational methodology applied reflects a necessary simplification to effectively manage this complexity. However, integrating semi-quantitative metrics could significantly enhance the interoperability of impact assessments across sectors. Future research can achieve greater consistency and comparability, enhancing the utility of economic data for decision-making and policy development. This work will build upon the foundation established by the economic data contained in the InvaCost database, and support the integration of monetary evaluations from European General Di-

rectorates, responsible for policy development and implementation. The ultimate aim is to enhance the comparability and interoperability of impact assessments across regulated sectors.

The primary assessment is intended to address these gaps and be regularly updated through the EASIN network, which will provide open and free access to IAS impacts through its web tools. This initiative offers an opportunity to inform policy to tackle more efficiently biological invasions. Within the context of the JRC EASIN, the assessment serves as a foundational resource for facilitating the exchange of critical information between policymakers and scientists and liaise with economic data on impacts (e.g. InvaPact).

A future direction could consider addressing spatial granularity of the primary assessment. While the current approach presents precautionary scenarios for each species, i.e. highest confidence for worst and best impacts, there is an increasing knowledge linking different impacts in various locations or even in the same location over time, influenced by rapid traits changes, driven by environmental and socio-economic context.

In addressing the impacts of IAS, it is crucial to understand and manage IAS impacts to sector domains, in a more integrated way. Assessments that consider impacts of IAS in multiple domains are essential for prioritising species in the broader policy context. This is true also within the environmental sector where different biodiversity initiatives are conducted, such as species protection and habitats restoration, ensuring more effective allocation of resources. This will allow users to link this information to repositories storing costs for IAS management, direct and indirect damages (e.g. InvaCost – Diagne et al. 2000, LIFE projects, Interreg). To this end, the InvaCost database has revealed significant gaps in research efforts, particularly in high-income regions and on certain taxa, such as animals, while often overlooking regions and species with potentially substantial but undocumented impacts (Diagne et al. 2021). This aligns with the findings in our paper, which highlight the lack of empirical evidence for numerous species in natural environments, particularly those with significant implications for agricultural pest management and biodiversity. The existing literature focus on mitigating specific impacts rather than exploring the underlying damages mechanisms parallels the gaps identified in InvaCost, suggesting a systematic oversight in comprehensively understanding the effects of IAS. To this end, the InvaCost database has shown significant biases in research efforts, particularly in high-income regions and certain taxa, such as animals, while often overlooking regions and species with potentially substantial but undocumented impacts (Diagne et al. 2021).

In addition to species-specific information, our approach is essential for identifying critical sectors requiring improved mitigation measures and for tailoring biosecurity plans to address the specific needs of each sector, while also emphasising the role of international cooperation in managing IAS threats (European Commission 2024). We encourage the scientific community to share their initiatives, work results and insights, to contribute to the primary assessment promoting access to this information for both policy and research purposes.

The commitment to this ongoing research, data sharing, and policy development within the JRC EASIN context ensures that these efforts remain dynamic and responsive to emerging challenges, ultimately contributing to European and global environmental protection initiatives and sustainability.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Use of AI

No use of AI was reported.

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Author contributions

Conceptualization: EG, CM, BM, ACC. Formal analysis: CM. Methodology: ACC, EG, CM, EC, GB, BM, ECB, FC. Validation: QG, SVA, SM, RS, LC, CP, ALN, CB, NVÁ, RMQ, SD, TA, MV, MHA, ERH. Writing – original draft: CM. Writing – review and editing: ALN, RS, TA, SD, LC, ACC, EG, MHA, SM, FC, MV, SVA, GB, NVÁ, CP, QG, CM, ERH, EC, BM, ECB, CB, RMQ.

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Data availability

Data is available through the European Alien Species Information Network (EASIN). Contact: jrc-easin@ec.europa.eu

References

Armitage CS, Sjøtun K, Jensen KH (2014) Correlative evidence for competition between *Fucus serratus* and the introduced chlorophyte *Codium fragile* subsp. fragile on the southwest coast of Norway. Botanica Marina 57(2): 85–97. https://doi.org/10.1515/bot-2013-0087

Barcellos L, Pham CK, Menezes G, Bettencourt R, Rocha N, Carvalho M, Felgueiras HP (2023) A concise review on the potential applications of *Rugulopteryx okamurae* macroalgae. Marine Drugs 21: 1–40. https://doi.org/10.3390/md21010040

Bassett IJ, Crompton CW (1982) The Biology of Canadian weeds.: 55.: *Ambrosia trifida* L. Canadian Journal of Plant Science 62: 1003–1010. https://doi.org/10.4141/cjps82-148

Blackburn TM, Essl F, Evans T, Hulme PE, Jeschke JM, Kühn I, Kumschick S, Mrugała A, Marková Z, Nentwig W, Pergl J, Pyšek P, Rabitsch W, Ricciardi A, Richardson DM, Sendek A, Vilà M, Wilson JRU, Winter M, Genovesi P, Bacher S (2014) A unified classification of alien species based on the magnitude of their environmental impacts. PLoS Biology 12(5): e1001850. https://doi.org/10.1371/journal.pbio.1001850

Boadie-Ampong M, Nishi M (2024) Exploring the benefits of invasive alien plant species for human well-being: A systematic review of the state-of-the-art and directions for prospective research. Discover Sustainability 5: e329. https://doi.org/10.1007/s43621-024-00552-4

Booy O, Cornwell L, Parrott D, Sutton-Croft M, Williams F (2017) Impact of biological invasions on infrastructure. Impact of biological invasions on ecosystem services: 235–247. https://doi.org/10.1007/978-3-319-45121-3_15

Bray JP, Hewitt CLR, Hulme PE (2024) Bridging aquatic invasive species threats across multiple sectors through one biosecurity. Bioscience 74: 440–449. https://doi.org/10.1093/biosci/biae049

Cannarozzi L, Paoli C, Vassallo P, Cilenti L, Bevilacqua S, Lago N, Scirocco T, Rigo I (2023) Donor-side and user-side evaluation of the Atlantic blue crab invasion on a Mediterranean lagoon. Marine Pollution Bulletin 189: e114758. https://doi.org/10.1016/j.marpolbul.2023.114758

Carneiro L, Hulme PE, Cuthbert RN, Kourantidou M, Bang A, Haubrock PJ, Bradshaw CJ, Balzani P, Bacher S, Latombe G, Bodey TW (2024) Benefits do not balance costs of biological invasions. Bioscience 74: 340–344. https://doi.org/10.1093/biosci/biae010

Cerveira I, Baptista V, Teodósio MA, Morais P (2022) What's for dinner? Assessing the value of an edible invasive species and outreach actions to promote its consumption. Biological Invasions 24: 815–829. https://doi.org/10.1007/s10530-021-02685-3

Chauvel B, Fried G, Follak S, Chapman D, Kulakova Y, Le Bourgeois T, Marisavljevic D, Monty A, Rossi J-P, Starfinger U et al. (2021) Monographs on invasive plants in Europe N° 5: *Ambrosia trifida* L. Botany Letters 168: 167–190. https://doi.org/10.1080/23818107.2021.1879674

Chinchio E, Crotta M, Romeo C, Drewe JA, Guitian J, Ferrari N (2020) Invasive alien species and disease risk: An open challenge in public and animal health. PLoS Pathogens 16: e1008922. https://doi.org/10.1371/journal.ppat.1008922

Çinar ME, Arianoutsou M, Zenetos A, Golani D (2014) Impacts of invasive alien marine species on ecosystem services and biodiversity: A pan-European review. Aquatic Invasions 9: 391–423. https://doi.org/10.3391/ai.2014.9.4.01

Clavero M, López V, Franch N, Pou-Rovira Q, Queral JM (2015) Use of seasonally flooded rice fields by fish and crayfish in a Mediterranean wetland. Agriculture, Ecosystems & Environment 213: 39–46. https://doi.org/10.1016/j.agee.2015.07.022

Cohen J (1960) A coefficient of agreement for nominal scales. Educational and Psychosocial Measurement 20: 37–46. https://doi.org/10.1177/001316446002000104

COM (2021) 628 final, Report from the Commission to the European Parliament and the Council on the review of the application of Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species.

Conway JR, Lex A, Gehlenborg N (2017) UpSetR: An R package for the visualization of intersecting sets and their properties. Bioinformatics 33(18): 2938–2940. https://doi.org/10.1093/bioinformatics/btx364

D'hondt B, Vanderhoeven S, Roelandt S, Mayer F, Versteirt V, Adriaens T, Ducheyne E, San Martin G, Grégoire J-C, Stiers I et al. (2015) Harmonia+ and Pandora+: Risk screening tools for potentially invasive plants, animals and their pathogens. Biological Invasions 17: 1869–1883. https://doi.org/10.1007/s10530-015-0843-1

Diagne C, Leroy B, Gozlan RE, Vaissière AC, Assailly C, Nuninger L, Roiz D, Jourdain F, Jarić I, Courchamp F (2020) InvaCost, a public database of the economic costs of biological invasions worldwide. Scientific Data 7: e277. https://doi.org/10.1038/s41597-020-00586-z

Diagne C, Leroy B, Vaissière AC, Gozlan RE, Roiz D, Jarić I, Salles JM, Bradshaw CJ, Courchamp F (2021) High and rising economic costs of biological invasions worldwide. Nature 592: 571–576. https://doi.org/10.1038/s41586-021-03405-6

EFSA (2023) The European Union One Health 2022 Zoonoses Report. EFSA Journal 21: e8442. https://doi.org/10.2903/j.efsa.2023.p211202

European Commission Joint Research Centre, Magliozzi C, Lucrezi S, Oficialdegui FJ, Melone B, Gervasini E, Cardoso AC (2024) Fostering transnational collaboration in IAS management to combat invasive alien species, Publications Office of the European Union. https://data.europa.eu/doi/10.2760/71881

Evans T, Kumschick S, Blackburn TM (2016) Application of the Environmental Impact Classification for Alien Taxa (EICAT) to a global assessment of alien bird impacts. Diversity & Distributions 22: 919–931. https://doi.org/10.1111/ddi.12464

Fleming LE, Depledge MH, Maycock B, Alcantara-Creencia L, Gerwick WH, Goh HC, Gribble MO, Keast J, Raps H, Solo-Gabriele H (2023) Horizon scan of oceans and human health. In: Oceans and Human Health. Elsevier, 729–742. https://doi.org/10.1016/B978-0-323-95227-9.00003-8

Gallardo B, Bacher S, Barbosa AM, Gallien L, González-Moreno P, Martínez-Bolea V, Sorte C, Vimercati G, Vilà M (2024) Risks posed by invasive species to the provision of ecosystem services in Europe. Nature Communications 15: e2631. https://doi.org/10.1038/s41467-024-46818-3

Haubrock PJ, Turbelin AJ, Cuthbert RN, Novoa A, Taylor NG, Angulo E, Ballesteros-Mejia L, Bodey TW, Capinha C, Diagne C et al. (2021) Economic costs of invasive alien species across Europe. NeoBiota 67: 153–190. https://doi.org/10.3897/neobiota.67.58196

Havel JE, Kovalenko KE, Thomaz SM, Amalfitano S, Kats LB (2015) Aquatic invasive species: Challenges for the future. Hydrobiologia 750: 147–170. https://doi.org/10.1007/s10750-014-2166-0

Hawkins CL, Bacher S, Essl F, Hulme PE, Jeschke JM, Kühn I, Kumschick S, Nentwig W, Pergl J, Pyšek P, Rabitsch W, Richardson DM, Vilà M, Wilson JRU, Genovesi P, Blackburn TM (2015) Framework and guidelines for implementing the proposed IUCN Environmental Impact Classification for Alien Taxa (EICAT). Diversity & Distributions 21: 1360–1363. https://doi.org/10.1111/ddi.12379

IPBES (2023) Summary for Policymakers of the Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. In: Roy HE, Pauchard A, Stoett P, Renard Truong T, Bacher S, Galil BS, Hulme PE, Ikeda T, Sankaran KV, McGeoch, MA, Meyerson LA, Nuñez MA, Ordonez A, Rahlao SJ, Schwindt E, Seebens H, Sheppard AW, Vandvik V (Eds) IPBES secretariat. Bonn. https://doi.org/10.5281/zenodo.7430692

Kang B-H, Shim S-I, Lee S-G, Kim K-H, Chung I-M (1998) Evaluation of *Ambrosia artemisiifolia* var. *elatior*, *Ambrosia trifida*, *Rumex crispus* for phytoremediation of Cu and Cd contaminated soil. Korean Journal of Weed Science 18: 262–267.

Kato-Noguchi H, Kato M (2024) Invasive Characteristics and Impacts of *Ambrosia trifida*. Agronomy 14: e2868. https://doi.org/10.3390/agronomy14122868

Katsanevakis S, Wallentinus I, Zenetos A, Leppäkoski E, Çinar M, Oztürk B, Grabowski M, Golani D, Cardoso A (2014) Impacts of marine invasive alien species on ecosystem services and biodiversity: A pan-European review. Aquatic Invasions 9: 391–423. https://doi.org/10.3391/ai.2014.9.4.01

Katsanevakis S, Rilov G, Edelist D (2018) Impacts of marine invasive alien species on European fisheries and aquaculture-plague or boon. CIESM Monograph 50: 125–132.

Kumschick S, Nentwig W (2010) Some alien birds have as severe an impact as the most effectual alien mammals in Europe. Biological Conservation 143: 2757–2762. https://doi.org/10.1016/j.biocon.2010.07.023

Lamb BT, McCrea AA, Stoodley SH, Dzialowski AR (2021) Monitoring and water quality impacts of an herbicide treatment on an aquatic invasive plant in a drinking water reservoir. Journal of Environmental Management 288: e112444. https://doi.org/10.1016/j.jenvman.2021.112444

Landis JR, Koch GG (1977) The measurement of observer agreement for categorical data. Biometrics 33: 159–174. https://doi.org/10.2307/2529310

Liebman M, Nichols VA (2020) Cropping system redesign for improved weed management: A modeling approach illustrated with giant ragweed (*Ambrosia trifida*). Agronomy 10: e262. https://doi.org/10.3390/agronomy10020262

Marchessaux G, Mangano MC, Bizzarri S, M'Rabet C, Principato E, Lago N, Veyssiere D, Garrido M, Scyphers SB, Sarà G (2023) Invasive blue crabs and small-scale fisheries in the Mediterranean sea: Local ecological knowledge, impacts and future management. Marine Policy 148: e105461. https://doi.org/10.1016/j.marpol.2022.105461

Mollot G, Pantel J, Romanuk T (2017) The Effects of Invasive Species on the Decline in Species Richness: A Global Meta-Analysis. Advances in Ecological Research. Elsevier, 61–83. https://doi.org/10.1016/bs.aecr.2016.10.002

Nentwig W, Kühnel E, Bacher S (2010) A generic impact-scoring system applied to alien mammals in Europe. Conservation Biology 24: 302–311. https://doi.org/10.1111/j.1523-1739.2009.01289.x

Nentwig W, Bacher S, Pyšek P, Vilà M, Kumschick S (2016) The generic impact scoring system (GISS): A standardized tool to quantify the impacts of alien species. Environmental Monitoring and Assessment 188: 1–13. https://doi.org/10.1007/s10661-016-5321-4

NNSS (2015) Rapid Risk Assessment. https://www.nonnativespecies.org/assets/Uploads/RSS_RA_Corbicula_fluminea.pdf

Nyumba TO, Sang CC, Olago DO, Marchant R, Waruingi L, Githiora Y, Kago F, Mwangi M, Owira G, Barasa R et al. (2021) Assessing the ecological impacts of transportation infrastructure

development: A reconnaissance study of the Standard Gauge Railway in Kenya. PLoS ONE 16: e0246248. https://doi.org/10.1371/journal.pone.0246248

Paint-Small VP (2013) Linking culture, ecology and policy: The invasion of Russian-olive (*Elaeagnus angustifolia* L.) on the Crow Indian reservation, south-central Montana, USA. PHD Thesis. Colorado State University.

Pfeiffer JM, Voeks RA (2008) Biological invasions and biocultural diversity: Linking ecological and cultural systems. Environmental Conservation 35: 281–293. https://doi.org/10.1017/S0376892908005146

Pyšek P, Hulme PE, Simberloff D, Bacher S, Blackburn TM, Carlton JT, Dawson W, Essl F, Foxcroft LC, Genovesi P et al. (2020) Scientists' warning on invasive alien species. Biological Reviews of the Cambridge Philosophical Society 95: 1511–1534. https://doi.org/10.1111/brv.12627

Rojas-Sandoval J, Ackerman JD, Marcano-Vega H, Willig MR (2022) Alien species affect the abundance and richness of native species in tropical forests: The role of adaptive strategies. Ecosphere 13: e4291. https://doi.org/10.1002/ecs2.4291

Roy HE, Rabitsch W, Scalera R, Stewart A, Gallardo B, Genovesi P, Essl F, Adriaens T, Bacher S, Booy O, Branquart E, Brunel S, Copp GH, Dean H, D'hondt B, Josefsson M, Kenis M, Kettunen M, Linnamagi M, Lucy F, Martinou A, Moore N, Nentwig W, Nieto A, Pergl J, Peyton J, Roques A, Schindler S, Schönrogge K, Solarz W, Stebbing PD, Trichkova T, Vanderhoeven S, van Valkenburg J, Zenetos A (2018) Developing a framework of minimum standards for the risk assessment of alien species. Journal of Applied Ecology 55: 526–538. https://doi.org/10.1111/1365-2664.13025

Roy HE, Tricarico E, Hassall R, Johns CA, Roy KA, Scalera R, Smith KG, Purse BV (2022) The role of invasive alien species in the emergence and spread of zoonoses. Biological Invasions 25: 1–16. https://doi.org/10.1007/s10530-022-02978-1

Shackleton RT, Richardson DM, Shackleton CM, Bennett B, Crowley SL, Dehnen-Schmutz K, Estévez RA, Fischer A, Kueffer C, Kull CA et al. (2019a) Explaining people's perceptions of invasive alien species: A conceptual framework. Journal of Environmental Management 229: 10–26.

Shackleton RT, Shackleton CM, Kull CA (2019b) The role of invasive alien species in shaping loc https://doi.org/10.1016/j.jenvman.2018.04.045 al livelihoods and human well-being: A review. Journal of Environmental Management 229: 145–157. https://doi.org/10.1016/j.jenvman.2018.05.007

Turbelin AJ, Hudgins EJ, Catford JA, Cuthbert RN, Diagne C, Kourantidou M, Roiz D, Courchamp F (2024) Biological invasions as burdens to primary economic sectors. Global Environmental Change 87: e102858. https://doi.org/10.1016/j.gloenvcha.2024.102858

Vanderbush B, Longhenry C, Lucchesi DO, Barnes ME (2021) A review of zebra mussel biology, distribution, aquatic ecosystem impacts, and control with specific emphasis on South Dakota, USA. Open Journal of Ecology 11: 163–182. https://doi.org/10.4236/oje.2021.112014

Vimercati G, Probert AF, Volery L, Bernardo-Madrid R, Bertolino S, Céspedes V, Essl F, Evans T, Gallardo B, Gallien L, González-Moreno P (2022) The EICAT+ framework enables classification of positive impacts of alien taxa on native biodiversity. PLoS Biology 20: e3001729. https://doi.org/10.1371/journal.pbio.3001729

Watts DA, Moore GW (2011) Water-use dynamics of an invasive reed, *Arundo donax*, from leaf to stand. Wetlands 31: 725–734. https://doi.org/10.1007/s13157-011-0188-1

Yan J, Li Y, Liang X, Zhang Y, Dawood MA, Matuli'c D, Gao J (2017) Effects of dietary protein and lipid levels on growth performance, fatty acid composition and antioxidant-related gene expressions in juvenile loach *Misgurnus anguillicaudatus.* Aquaculture Research 48: 5385–5393. https://doi.org/10.1111/are.13352

Supplementary material 1

Supplementary information

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Data type: docx

Explanation note: **table S1.** Confidence levels based on the strength of evidence. Adapted from Katsanevakis et al. (2014). **table S2.** List of IAS assessed by workshop participants. **fig. S1.** OOverview of the number of IAS assessed across environments and taxonomic groups. **fig. S2.** Domains (see definitions in the manuscript) identified during the workshop for the 49 IAS. **fig. S3.** IAS with reported positive and negative impacts across sector domains during the workshop.

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